Rules for the Classification of Methanol Fuelled Ships

July 2021

Lloyd's Register

A guide to the Rules

and published requirements

Rules for the Classification of Methanol Fuelled Ships

Introduction

The Rules are published as a complete set.

Rules updating

The Rules are published periodically and changed through a system of Notices between releases.

July 2021

PLEASE NOTE: No technical changes have been made to this Rule set, only the date has been updated.

Section 1
General

1.1 Purpose and scope

1.1.1 This document provides requirements for machinery using methanol as a fuel. The aim of the requirements is to provide a level of safety in respect of the ship's occupants and a level of dependability in respect of the ship's essential services, such as propulsion and electrical power that is commensurate with conventional oil-fuelled propulsion and auxiliary machinery.

1.1.2 These requirements are in addition to the applicable requirements of the *Rules and Regulations for the Classification of Ships*, (hereinafter referred to as the Rules for Ships) as well as other LR Rules where applicable, and all relevant Statutory Conventions.

1.1.3 The Rules do not repeat the general requirements for fire safety as stated in statutory conventions. These Rules do however include fire safety requirements additional to those stated in the statutory conventions specific to the use of methanol as fuel.

1.1.4 Additional requirements may be imposed by the National Administration with which the ship is registered and/or by the Administration within whose territorial jurisdiction the ship is intended to operate.

1.1.5 Any proposed deviations from the requirements of these Rules will be specially considered as part of the risk-based studies required by *Ch 1, 3 Risk-based studies*.

1.1.6 Periodic survey regulations for methanol-fuelled ships are located in the relevant requirements of the Rules for Ships,*Pt 1, Ch 3, 24 Fuel installations using gases or other low-flashpoint fuels*

1.2 Class notation

1.2.1 Ships complying with the requirements of these Rules will be eligible for assignment of the **LFPF(GF, ML)** machinery notation:

LFPF(GF, ML) Assigned to ships other than liquefied gas carriers and tankers, where the main propelling and/or auxiliary machinery is designed to operate on methanol fuel. The notation also indicates that the methanol-fuelled machinery has been constructed, arranged, installed and tested in accordance with LR's Rules and Regulations.

1.3 Definitions

1.3.1 In the context of these Rules, the following definitions apply:

1.3.2 **Area** means a defined location. An area can be on open deck. An area can be open, semi-enclosed or enclosed. An area can be a space below deck. An area can be hazardous or non-hazardous.

1.3.3 **Dependability** is as defined in IEC 60050(191): *Quality vocabulary — Part 3: Availability, reliability and maintainability terms — Section 3.2: Glossary of international terms*. It is the collective term used to describe the availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance and relates to essential services as agreed with Lloyd's Register. Note: Dependability is used only for general descriptions in non-quantitative terms.

1.3.4 **Dual-fuel engine** means an engine that uses fuel covered by these Rules (with pilot fuel) and fuel oil. fuel oils may include distillate and residual fuels.

1.3.5 **Enclosed space** is any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally. In practical terms, this is a space bounded either on all sides, or all but one side, by bulkheads and decks, irrespective of openings, such that the required ventilation rate to prevent the accumulation of pockets of stagnant air cannot be achieved by natural ventilation alone, *see Ch 1, 1.3 Definitions 1.3.24*.

1.3.6 **Explosive gas atmosphere** is a mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour that, after ignition, permits self-sustaining flame propagation.

1.3.7 **Fuel**, unless otherwise stated refers to methanol fuel as a liquid, vapour or both.

1.3.8 **Fuel storage hold space** is an enclosed or semi-enclosed area in which an independent methanol fuel storage tank is located.

1.3.9 **Hazardous area** as defined in the IEC 60079 series, means an area (*see Ch 1, 1.3 Definitions 1.3.2*) in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus. Hazardous areas are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, as follows:

(a) **Zone 0** is an area in which an explosive gas atmosphere is present continuously, for long periods or frequently;
(b) **Zone 1** is an area in which an explosive gas atmosphere is likely to occur in normal operation occasionally; and
(c) **Zone 2** is an area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

1.3.10 **Independent tank** means a fuel-containment envelope, which is not contiguous with, or part of, the hull structure. An independent tank is built and installed so as to eliminate whenever possible (or in any event to minimise) its stressing as a result of stressing or motion of the adjacent hull structure.

1.3.11 **Integral tank** means a fuel-containment envelope which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

1.3.12 **Master fuel valve** is a remotely activated and system activated valve in the fuel supply line to the consumers which is located outside the machinery space of category A and is immediately downstream of the methanol supply equipment.

1.3.13 **Consumers** refers to methanol-fuelled machinery which includes:

(a) dual-fuelled engines capable of burning fuel oil or methanol fuel - using pilot oil ignition – alone or as a combination of both;
(b) single-fuelled engines capable of burning only methanol alone;
(c) dual-fuel burner systems for boilers capable of burning fuel oil or methanol fuel alone or as a combination of both.

1.3.14 **Non-hazardous area** means an area (*see Ch 1, 1.3 Definitions 1.3.2*) in which an explosive gas atmosphere is not expected to be present in quantities sufficient to require special precautions for the construction, installation and use of apparatus.

1.3.15 **Reasonably foreseeable abnormal condition** is an event, incident or failure that:

- has happened and could happen again; and
- is planned for (e.g. emergency actions cover such a situation, maintenance is undertaken to prevent it, etc.).

1.3.16 **Risk** is the combination of the likelihood of an event and its consequence. Likelihood may be expressed as a probability or a frequency.

1.3.17 **Risk assessment** is the evaluation of likelihood and consequence, together with a judgement on the significance of the result, *see* IEC/ISO 31010: *Risk management, risk assessment techniques*.

1.3.18 **Rules for Ships** means *Rules and Regulations for the Classification of Ships*.

1.3.19 **Semi-enclosed space** is a space limited by decks and/or bulkheads in such a manner that the natural conditions of ventilation in the spaces are noticeably different from those obtained on open deck. In practical terms, this is a space which is open on two opposing sides, but where the natural ventilation conditions within the space are restricted by structures such as decks, bulkheads or windbreaks in a manner such that they are significantly different from those obtained on an open deck, and where dispersion of vapour may be impeded.

1.3.20 **Service profile** for the purposes of these Rules is the machinery power/speed operational envelope indicating all the intended operational points applicable to the use of methanol as fuel and any short-term high power operation.

1.3.21 **Single fuel engine** means an engine that uses only methanol as fuel.

1.3.22 **Single failure** is where loss of intended function occurs through one fault or action.

1.3.23 **Source of release** is a point or location from which a flammable vapour or liquid is potentially released, for example a valve or detachable pipe joint, or a compressor or pump seal in the fuel supply system.

1.3.24 **Space** means an enclosed or semi-enclosed area, room or location. Typically spaces are below deck. *See also Ch 1, 1.3 Definitions 1.3.2*.

1.3.25 **Tank master isolation valve** is a remotely operated valve on the outlet from a fuel storage tank which is located as close as possible to the tank outlet location.

Section 2
Submission requirements

2.1 Documentation required for design review

2.1.1 In addition to the documentation required by the relevant Chapters of the Rules for Ships, the following shall be submitted:

(a) Design statement that defines the service profile of the ship, together with a description of the arrangements, essential services as agreed by LR and the intended operating capability and functionality of the main propulsion and auxiliary systems that use methanol as fuel.

(b) Risk-based studies undertaken to a recognised Standard and in accordance with LR's ShipRight procedure *Assessment of Risk Based Designs* and associated annexes. The studies shall be documented so that the risks and how they are eliminated or mitigated are clearly identified, and an appropriate level of safety, dependability and hazardous areas classification is demonstrated, *see Ch 1, 3 Risk-based studies*.

(c) Arrangement plans for methanol bunkering stations, fuel storage tanks, fuel supply equipment and consumers, and their location relative to high fire risk areas, accommodation, service and control spaces, water ballast, fuel oil, and other tanks containing flammable substances.

(d) Process Flow Diagrams (PFDs) and Piping and Instrumentation Diagrams (P&IDs) for all fuel containing equipment. This shall include all pipework and equipment from the bunker connection through to the engine.

(e) Hazardous area plans indicating the location of hazardous areas and their openings, access and ventilation arrangements. To supplement these plans, the documentation from the classification study described in *Ch 1, 3.5 Hazardous areas classification study* shall also be submitted.

(f) Schedule of electrical and mechanical equipment located in hazardous areas.

(g) Fuel supply system piping and equipment plans. Details shall include: system design and general arrangements; piping design including installation; ducting; valves and fittings; filters; pressure relief; purging arrangements; pumps and heat exchangers.

(h) Plans and details of fuel storage tanks, holding tanks and pressure vessels, including filling, discharge, relief arrangements and tank penetrations.

(i) Piping fatigue analysis, *see Ch 1, 7.1 General 7.1.2*.

(j) Ventilation system plans for the machinery spaces, machinery enclosures or casings including air-locks, pipe ducting and any dampers in them, closing appliances and the position of the controls for stopping the system. Plans shall indicate hazardous areas where appropriate.

(k) Enclosures or casing plans for consumers and any air locks where required.

(l) Fixed methanol detection and alarm system plans.

(m) Description of emergency shutdown arrangements, including a list of control, monitoring and alarm points, and the messages to be displayed for each alarm.

(n) Operating manuals that describe the installation particulars, together with operating and maintenance instructions. Procedures for modifications to control systems to be included. Equipment manufacturers' instructions shall include the drawings and diagrams necessary for putting into service, maintenance, inspection, checking of correct operation, repair of the machinery, the use of correct spares and tools, and useful instructions with regard to safety.

(o) Description and plans of fuel control and monitoring systems and fuel changeover arrangements for dual-fuelled machinery, including line diagrams of control circuits and lists of monitoring, control and alarm points.

(p) Quality plans for sourcing, design, installation and testing of all components and equipment used in the fuel system.

(q) Evidence of type testing of the engine with electronic controls or a proposed test plan at the builders with the electronic controls operational, to verify suitability of the electronic control system and correct functioning during normal operation and identified failure modes.

(r) Schedule of testing at engine builders and commissioning prior to sea trials, to demonstrate that the consumers are capable of operating as described in the design statement, including any testing required to verify the safeguards determined in the risk-based studies, *see Ch 1, 3 Risk-based studies*. The test schedules shall identify all modes of operation and the sea trials shall include typical port manoeuvres under all intended engine/turbine operating modes.

(s) A cause and effect diagram to indicate the results of activation of each shutdown, shut-off and cut-out associated with the fuel system including engine operation and bunkering.

(t) A suitable testing and inspection plan for fuel storage and supply system trials.

(u) Methanol bunkering equipment arrangements and plans, operational procedures and maintenance instruction manuals.

(v) Structural fire protection plan showing the main fire zones, the fire compartmentation bulkheads and decks within the main fire zones, including fire risk categorisation of spaces and class of all fire divisions. The plan should also allow identification of different types of space and their use.

(w) Plans showing the details of fire-fighting and fire protection systems as required by Section 10 and the applicable statutory requirements.

(x) A plan of the Alcohol Resistant Aqueous Film Forming Foam (ARAFFF) system. The plan shall show details of system arrangement, including calculations for the quantities of the media used and the proposed rates of application.

(y) Fire Safety Operational Booklet including Methanol safety/emergency procedure. Refers SOLAS II/2 Reg. 16.2.

(z) For existing vessels, details of any structural modifications are to be submitted.

Section 3
Risk-based studies

3.1 Purpose

3.1.1 The purpose of the risk-based studies is to:

(a) evaluate safety considerations that are specific to the application;

(b) evaluate dependability of essential services;

(c) specially consider arrangements which deviate from the requirements of these Rules.

3.2 System safety risk assessment

3.2.1 A system safety risk assessment shall be undertaken. The objectives of the assessment are to:

(a) evaluate safety risks associated with the use of methanol that are application specific, such as the specific location of tanks, machinery, equipment and accommodation;

(b) evaluate safety risks associated with the use of methanol where it is proposed to deviate from the requirements of these Rules;

(c) demonstrate that an appropriate level of safety is achieved that is commensurate with conventional oil-fuelled propulsion and auxiliary machinery.

3.2.2 Where the risks cannot be eliminated, an inherently safer design shall be sought in preference to operational/procedural controls. This shall focus on engineered prevention of failure (e.g. a minimised number of connections, increased reliability, and redundancy). Where this cannot be achieved or is insufficient, protection of occupants should focus on:

(a) firstly, passive means (e.g. physical barriers, separation, absence of ignition sources);
(b) secondly, active means (e.g. detection, isolation, ventilation and extinguishment).

Both passive and active means may be required to demonstrate an appropriate level of safety.

3.2.3 The assessment may identify the need for additional safety measures in addition to those specifically stated in these Rules. Where additional safety measures are identified, evidence is to be provided that demonstrates how they are implemented and validated.

3.2.4 As a minimum, the scope of the assessment shall consider:

(a) normal operation, start-up, normal shutdown, non-use, and emergency shutdown of the system;
(b) physical tank, machinery and equipment layout, arrangements and location;
(c) foreseeable mechanical failures, electrical failures and human errors.

3.2.5 The assessment shall be undertaken to a recognised Standard (e.g. ISO 31010, *Risk management – Risk assessment techniques*) and in accordance with LR's ShipRight procedure *Assessment of Risk Based Designs* and associated annexes.

3.3 System dependability assessment

3.3.1 A system dependability assessment shall be undertaken. The objectives of the assessment are to:

(a) demonstrate the dependability of the system during all normal and reasonably foreseeable abnormal conditions where essential services are reliant upon the system for their intended operation; and
(b) demonstrate that an appropriate level of dependability is achieved that is commensurate with conventional oil-fuelled machinery.

3.3.2 As a minimum, the scope of the assessment shall consider:

(a) the redundancy of fuel storage and supply; and
(b) the reliability and availability of machinery, equipment and components to maintain essential services.

3.3.3 Essential services include but may not be limited to those defined in the Rules for Ships, *Pt 6, Ch 2, 1.6 Definitions 1.6.1* and the items of equipment listed in the Rules for Ships, *Pt 5, Ch 1, 1.1 Machinery and equipment to be constructed under survey 1.1.1*.

3.3.4 The assessment shall be undertaken to a recognised Standard (e.g. IEC 60300-3-1, *Dependability management Part 3-1: Application guide – Analysis techniques for dependability – Guide on methodology*).

3.4 Failure modes and effects analysis (FMEA) of the critical system elements

3.4.1 An FMEA shall be undertaken on key components of the system as identified in the system safety risk assessment (e.g. may include the tank master isolation valve and/or the master fuel valve). The objectives of the analysis are to identify:

- potential failures;
- consequences of failure;
- means to eliminate or prevent failure;
- means to eliminate or minimise consequences.

3.4.2 The analysis may identify the requirement for safety measures in addition to those specifically stated in these Rules. Where additional safety measures are identified, evidence is to be provided that demonstrates how they are implemented and validated.

3.4.3 As a minimum, the scope of the analysis shall consider the 'fail safe' condition, location and arrangement of the critical system elements.

3.4.4 The analysis shall be undertaken to a recognised Standard (e.g. as outlined in ISO 31010: *Risk management - Risk assessment techniques*).

3.5 Hazardous areas classification study

3.5.1 A hazardous areas classification study shall be undertaken. The objective of the study shall identify areas or spaces in which a flammable/explosive atmosphere is present or may be expected to be present, such that potential sources of ignition can be eliminated or controlled, and access to such areas restricted.

3.5.2 The scope of the study shall consider all machinery and equipment which could represent a source of release of fuel in:

(a) normal operation, start-up, normal shutdown, non-use, and emergency shutdown of the fuel system;

(b) equipment intended for recovery from unintended releases of fuel.

3.5.3 The study shall be undertaken by suitably qualified and experienced personnel to a recognised Standard; IEC 60079-10-1: *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*.

3.6 System hazard and operability study (HAZOP)

3.6.1 A HAZOP study shall be undertaken. The objectives of the study are to:

(a) identify potential deviations from the intended operation of the fuel system;
(b) identify the causes of each deviation, and the consequences for safety (*see Ch 1, 3.2 System safety risk assessment* and *Ch 1, 3.4 Failure modes and effects analysis (FMEA) of the critical system elements*) and dependability (*see Ch 1, 3.3 System dependability assessment*);
(c) list safeguards to minimise causes and consequences;
(d) determine and recommend if further safeguards should be considered.

3.6.2 Using a detailed piping and instrumentation diagram (P&IDs) and supporting information and plans, the scope of the study shall consider normal operation, start-up, normal shutdown, non-use, and emergency shutdown of the fuel system.

3.6.3 The study shall be undertaken to a recognised Standard (e.g. ISO 31010: *Risk management – Risk assessment techniques*) in accordance with LR's ShipRight procedure *Assessment of Risk Based Designs* and the associated annexes.

3.7 Bunkering safety study

3.7.1 A bunkering safety study shall be undertaken. The objectives of the study are to review the bunkering equipment and arrangements, so as to:

(a) identify causes and safety consequences of potential fuel releases during connection, preparation and disconnection of bunkering equipment, and during transfer of fuel;
(b) list safeguards to minimise causes and consequences;
(c) determine and recommend if further safeguards or procedural changes should be considered.

3.7.2 The study shall be undertaken to a recognised Standard (e.g. ISO 31010: *Risk management – Risk assessment techniques*) in accordance with LR's ShipRight procedure *Assessment of Risk Based Designs* and the associated annexes.

3.8 Other risk-based studies

3.8.1 Other studies may be required as identified by the risk assessment (*see Ch 1, 3.2 System safety risk assessment*), and these may identify the requirement for safety measures in addition to those specifically stated in these Rules. Where additional safety measures are identified, evidence is to be provided that demonstrates how they are implemented and validated.

■ *Section 4*
Materials, components and equipment

4.1 General

4.1.1 Materials, components and equipment to be used in the construction of bunkering stations, fuel storage tanks, fuel supply equipment and consumers shall:

(a) be suitable for their intended use;
(b) be considered in the risk-based studies, *see Ch 1, 3 Risk-based studies*;
(c) satisfy the requirements of this Section.

4.2 Materials

4.2.1 Except where otherwise required by these Rules, the materials shall comply with the relevant requirements of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk.* (hereinafter referred to as the Rules for Ships for Liquid Chemicals)

4.2.2 Materials that are sensitive to methanol and methanol containing water, such as aluminium alloys, galvanised steel, lead alloys, Nitrile, Butyl and others shall not be used in systems containing fuel.

4.2.3 Where stainless steel is specified, it shall be an austenitic or duplex type and comply with the appropriate requirements of the Rules for Materials. Alternative grades of stainless steel may be accepted provided they comply with National or Proprietary specifications and are suitable for the intended purpose. Austenitic stainless steels should not be used where methanol contains water which may contain chlorides.

4.2.4 Novel steel materials such as austenitic manganese steels may be considered on a case by case basis.

4.2.5 Tank coatings and tank access hatch sealing materials shall be resistant to:

(a) methanol liquid;
(b) methanol where it may contain water;
(c) methanol vapour;
(d) gases used for inerting.

4.3 Components and equipment

4.3.1 Electrical equipment and components intended for use in hazardous areas shall be of a certified safe type in accordance with *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts* of the Rules for Ships or an acceptable and relevant National or International Standard.

4.3.2 Mechanical equipment and components intended for use in a hazardous area shall be designed, constructed and installed to ensure that they are:

(a) capable of safe operation in normal or foreseeable hazardous conditions;
(b) capable of preventing the formation of a hazardous and toxic atmosphere that may be produced or released by the components or equipment;
(c) capable of preventing the ignition of hazardous atmospheres, taking into account the nature of every electrical and non-electrical source of ignition.

Section 5
Location and arrangement of spaces

5.1 General

5.1.1 The locations and arrangements of bunkering stations, fuel storage tanks, fuel supply equipment and consumers shall be evaluated in the risk-based studies, *see Ch 1, 3 Risk-based studies*, and be acceptable to LR. The locations and arrangements shall satisfy the requirements of this Section.

5.1.2 Escape routes shall not pass through hazardous areas.

5.2 Methanol bunkering station

5.2.1 Methanol bunkering stations are not to be used for any other purpose than bunkering methanol fuel.

5.2.2 Bunkering stations on open deck shall be located in a naturally well-ventilated area and protected from possible mechanical damage.

5.2.3 Bunkering stations shall be physically separated or structurally shielded from accommodation, service areas and control stations.

5.2.4 Bunkering stations shall not be adjacent to, above or below:

(a) accommodation spaces;
(b) service spaces;
(c) control stations.

5.3 Fuel storage tanks

5.3.1 Fuel storage tanks can be integral tanks or independent tanks, *see Ch 1, 1.3 Definitions*.

5.3.2 Fuel storage tanks shall not be located within the accommodation area or high fire risk spaces such as machinery spaces of category A.

5.3.3 No part of the outer extent of fuel storage tanks shall be less than 800mm inboard from the ship shell side or from the boundary of any adjacent space, except as otherwise allowed by *Ch 1, 5.3 Fuel storage tanks 5.3.6*.

5.3.4 Fuel storage tanks shall be protected against the effects of fire and heat when adjacent compartments are high fire risk/ fire load spaces and the design details shall be considered in the risk-based studies.

5.3.5 Spaces forward of the collision bulkhead (forepeak) and/or, aft of the aftermost bulkhead (aft peak) shall not be arranged as fuel storage tanks.

5.3.6 Integral fuel storage tanks shall be surrounded by a cofferdam where not bounded by bottom shell plating or fuel pump rooms.

5.3.7 Where cofferdams surrounding integral fuel storage tanks are water filled, they shall be specially considered in the risk-based studies, *see Ch 1, 3.1 Purpose 3.1.1.(c)*.

5.3.8 Independent fuel storage tanks:

(a) on open deck shall be located in a naturally well-ventilated area;
(b) may be located in enclosed or semi-enclosed fuel storage hold spaces.

5.3.9 Independent fuel storage tanks on open deck shall be surrounded by coamings and shall be provided with means for safely draining accidental spills, *see Ch 1, 7.3 Drainage arrangements*.

5.3.10 "Independent fuel storage tanks and hold spaces shall not be adjacent to, or below accommodation spaces, service spaces or control stations, where practicable."

5.4 Fuel supply equipment

5.4.1 All equipment containing fuel that is provided for supply to consumers shall be located in a dedicated space (e.g. a pump room) and these spaces shall be:

(a) considered hazardous;
(b) gastight and liquid-tight;
(c) provided with approved piping and cabling penetrations;
(d) located outside of the machinery space.

5.4.2 The fuel supply system and equipment shall not be adjacent to accommodation spaces, service spaces or control stations, where practicable.

5.5 Methanol-fuelled consumer equipment

5.5.1 Consumers and the associated supply piping shall be arranged so that the machinery spaces in which they are located are non-hazardous, *see Ch 1, 6 System design* .

5.6 Access

5.6.1 Direct access from a non-hazardous space to a hazardous space is not permitted. Where access from a non-hazardous space to a hazardous space is required for operational reasons, an air-lock shall be provided.

5.6.2 Air-locks shall be:

(a) of simple geometric form;
(b) provided with clear passage;
(c) comprise of two self-closing gastight steel doors.

5.6.3 Air-lock doors shall be:

(a) spaced at least 1,5 m but no more than 2,5 m apart;
(b) provided without any hold-back arrangements;
(c) capable of maintaining the differential pressure, *see Ch 1, 5.6 Access 5.6.4*.

5.6.4 The air-lock space shall be maintained with a differential pressure and shall ensure that no fuel can be released to non-hazardous spaces in the event of a fuel release into the hazardous space.

5.6.5 The air-lock space shall be mechanically ventilated from a non-hazardous area.

5.6.6 The air-lock doors shall be monitored, *see Ch 1, 8.2 Control, alarm and safety functions 8.2.13*.

5.6.7 Mechanical ventilation to the air-lock shall be monitored, *see Ch 1, 8.2 Control, alarm and safety functions 8.2.14*.

5.6.8 The air-lock space shall be monitored for flammable vapour, *see Ch 1, 8.4 Methanol vapour detection 8.4.1.(c)*.

5.6.9 Electrical equipment that is not of the certified safe type and is located in non-hazardous spaces protected by air-locks shall be de-energised in case of loss of overpressure in the space.

5.6.10 Essential equipment required for safety shall not be de-energised upon loss of overpressure in the space and shall be of a certified safe type. This may include lighting, fire detection, public address, general alarms systems.

5.6.11 Electrical equipment which is not of the certified safe type for propulsion, power generation, manoeuvring, anchoring and mooring equipment as well as the emergency fire pumps shall not be located in spaces to be protected by air-locks.

5.6.12 Fuel storage tanks and surrounding cofferdams shall have suitable access from open deck for cleaning, maintenance, inspection and purging of fuel, except as given in *Ch 1, 5.3 Fuel storage tanks 5.3.8* and *Ch 1, 5.3 Fuel storage tanks 5.3.9*.

5.6.13 The pump room shall have an independent access direct from open deck. An air-lock shall be provided where this is not practicable.

5.6.14 For fuel storage tanks and cofferdams without direct access from open deck, the arrangements shall be such to ensure that, these spaces are free from flammable and toxic vapour or other gases that represent a hazard to the crew before any access hatch is opened.

5.6.15 For fuel storage tanks or cofferdams without direct access from open deck, the entry space shall comply with the following:

(a) The entry space shall be well ventilated;
(b) The entry space shall have sufficient open area around the fuel storage tank hatch for efficient evacuation and rescue operation.

5.6.16 Direct access to fuel storage tanks or cofferdams from accommodation spaces, service spaces, control stations and machinery spaces of category A will not be accepted. Access from cargo spaces may be accepted, dependent upon the types of cargo intended to be carried, and if the area is capable of being cleared of cargo and cargo operations suspended.

5.6.17 The area around independent fuel storage tanks shall be sufficient to carry out maintenance, inspections, evacuation and rescue operations.

5.6.18 Horizontal hatches or openings to or within fuel storage tanks or cofferdams shall have a minimum clear opening of 600 X 600 mm that also facilitates the hoisting of an injured person from the bottom of the tank/cofferdam.

5.6.19 For access through vertical openings providing main passage through the length and breadth within fuel storage tanks and cofferdams, the minimum clear opening shall not be less than 600 X 800 mm at a height of not more than 600 mm from bottom plating unless gratings or footholds are provided. Smaller openings may be accepted provided evacuation of an injured person can be demonstrated.

5.6.20 Maintenance hatches or removable panels providing access to enclosed spaces considered as hazardous, such as cofferdams, shall be provided with suitable seals to prevent the passage of fuel vapour when closed. The sealing arrangements on hatches and panels shall be capable of being tested for gas-tightness following maintenance.

5.6.21 Access hatch seals shall be secured in place.

5.7 Ventilation and pressurisation

5.7.1 Ventilation and pressurisation shall comply with the requirements of IEC 60092-502: *Electrical installations in ships – Part 502: Tankers – Special features*, the Rules for Ships, *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts* and these Rules.

5.7.2 Ventilation arrangements shall be such that the required ventilation capacity can be maintained under all foreseeable operating conditions, including single failure in equipment or control system.

5.7.3 All enclosed hazardous areas, except for cofferdams (*see Ch 1, 6.4 Cofferdams*), shall be provided with fixed mechanical ventilation of negative pressure that has a capacity of at least 30 air changes per hour under all foreseeable operating conditions, including a single failure in equipment or control system. The arrangements shall be such that there will be no regions of stagnant air within the ventilated space.

5.7.4 Air supplied for ventilation shall be in addition to the air supplied for combustion in consumers.

5.7.5 "Ventilation exhausts shall discharge to atmosphere at least 3 m from the nearest air intakes or open decks that are accessible to personnel, or openings to accommodation and enclosed working spaces, and from any possible source of ignition,

to ensure that any such opening, air intake or source of ignition lies outside the hazardous area associated with the ventilation exhaust, as identified by *Ch 1, 3.5 Hazardous areas classification study*.

5.7.6 Fans located in hazardous areas or in ventilation ducts serving hazardous areas shall be of the non-sparking type, in accordance with *Pt 5, Ch 15, 1.9 Non-sparking fans for hazardous areas* of the Rules for Ships.

5.7.7 'Fail-safe' automatic closing fire dampers of an approved type shall be fitted in all ventilation trunks serving hazardous areas. The characteristics of the 'fail-safe' operation shall be evaluated, not only on the basis of the function of the fire damper, but also the availability of the machinery and systems within the space that it serves.

5.8 Hazardous areas

5.8.1 In order to facilitate the selection of appropriate electrical apparatus, mechanical equipment and the design of the electrical and mechanical installations, hazardous areas shall be identified and classified into zones **0, 1** and **2**.

5.8.2 The hazardous areas identified in *Ch 1, 5.8 Hazardous areas 5.8.4* and*Ch 1, 5.8 Hazardous areas 5.8.5* are only valid for the following assumptions. If (a) or (b) are not met, hazardous areas shall be determined in accordance with *Ch 1, 3.5 Hazardous areas classification study*:

(a) ventilation is supplied at least 30 air changes per hour;
(b) fuel supply pressure does not exceed 10 bar.

5.8.3 Hazardous areas of **zone 0** include, but are not limited to:

(a) the interior of fuel tanks;
(b) the interior of pipework for pressure-relief and venting systems for fuel tanks;
(c) the interior of pipes and equipment containing fuel.

5.8.4 Hazardous areas of **zone 1** include, but are not limited to:

(a) cofferdams;
(b) enclosed or semi-enclosed bunker stations;
(c) enclosures or compartments containing fuel valves;
(d) areas on open deck or semi-enclosed spaces on deck, within 3 m of ventilation outlets of spaces identified in (a), (b) and (c);
(e) areas on open deck or semi-enclosed spaces on deck, within the vicinity of any fuel storage tank outlet intended for the passage of large volumes of fuel (e.g. fuel containment pressure relief valves). This hazardous area is defined as a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet and within a hemisphere of 6 m radius below the outlet;
(f) areas on open deck, or semi-enclosed spaces on deck, within 3 m of;
    (i) any fuel storage tank outlet,
    (ii) any vapour outlet,
    (iii) bunker manifold valve,
    (iv) other fuel valve,
    (v) fuel pipe flange,
    (vi) fuel pump-room ventilation outlets,
    (vii) tank openings for pressure release provided to permit the flow of small volumes of vapour mixtures caused by thermal variation;
(g) areas on open deck or semi-enclosed spaces on deck, within 1,5 m of compressor and pump room entrances, pump and compressor rooms, and bunker stations;
(h) areas on open deck or semi-enclosed spaces on deck, within 1,5 m of ventilation inlets and other openings into **zone 1** spaces;
(i) areas on open deck within spillage coamings surrounding methanol bunker manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;
(j) areas within 2,4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

5.8.5 Hazardous areas of **zone 2** include, but are not limited to:

(a) areas within 1,5 m of surrounding open or semi-enclosed spaces of **zone 1**, other than those mentioned in*Ch 1, 5.8 Hazardous areas 5.8.5.(b)*, *Ch 1, 5.8 Hazardous areas 5.8.5.(c)* and *Ch 1, 5.8 Hazardous areas 5.8.5.(d)*;
(b) areas 4 m beyond the cylinder and 4 m beyond the sphere defined in *Ch 1, 5.8 Hazardous areas 5.8.4.(e)*;
(c) areas 3 m beyond the areas in *Ch 1, 5.8 Hazardous areas 5.8.4.(h)* up to a height of 2,4 m above the deck;

(d) air-locks protecting a non-hazardous area from a **zone 1** area.

Section 6
System design

6.1 General

6.1.1 The system design, including methanol bunkering stations, fuel storage tanks, supply equipment and consumers, shall be subject to risk-based studies, *see Ch 1, 3 Risk-based studies*, and acceptable to LR. The system design is also to satisfy the requirements of this Section.

6.1.2 The design and construction of methanol-fuelled consumers shall permit stable and complete combustion under all expected operating conditions. The requirements are applicable to methanol-fuelled consumers, for either propulsion or auxiliary purposes, and either a single (methanol) fuel or dual-fuel type, *see Ch 1, 1.3 Definitions*.

6.1.3 Where power for the propulsion of the ship or other essential services is solely dependent on methanol-fuelled power generation machinery or equipment, no fewer than two independent sources of power shall be provided so that one source is retained in operation or is capable of being brought into operation in the event of unintended loss of one of the methanol-fuelled power units. Complete loss of power for propulsion and essential systems is not acceptable, *see Ch 1, 1.1 Purpose and scope 1.1.1*. Alternative arrangements (e.g. single engine installations) may be considered where supported by risk-based studies that demonstrate an equivalent level of dependability to a conventional fuel oilled engine.

6.1.4 A single failure within the fuel supply system shall not lead to a leakage into a non-hazardous area.

6.1.5 Mechanical and electrical equipment located within hazardous areas shall be limited to that considered necessary for operational purposes, *see also Ch 1, 4.3 Components and equipment*.

6.1.6 Machinery and equipment within hazardous areas shall be designed and installed to provide ease of access for inspection and maintenance.

6.1.7 At all locations where personnel may come into contact with methanol, an eyewash station and a shower shall be provided.

6.2 Methanol bunkering system

6.2.1 Bunkering operations shall be capable of being controlled from a safe location where tank instrumentation, including level indicators, is provided.

6.2.2 A manually operated stop valve and a remotely operated shutdown valve in series, or a combined manually operated and remote shutdown valve, shall be fitted in every bunkering line/pipe, close to the supply connection point. The remotely operated valve shall be capable of being operated locally from the bunkering control station or any other suitable safe location.

6.2.3 Bunkering lines/pipes shall not pass through accommodation, service spaces or control stations. Where bunkering lines/pipes pass through a non-hazardous area, they shall be double-walled piping or located in a ventilated gastight duct, *see Ch 1, 7.2 Piping design 7.2.16*.

6.2.4 If the pressure is lost in the annulus of double-walled piping or ventilation is lost in ventilated ducting, audible and visual alarms shall be provided at the bunkering control station, *see Ch 1, 8 Control, alert and safety systems* .

6.2.5 Connections and piping shall be positioned and arranged so that any damage to the fuel piping does not cause damage to the ship's fuel storage tanks resulting in an uncontrolled fuel discharge.

6.2.6 Arrangements shall be provided to:

(a) drain any fuel from pump suctions and bunkering lines/pipes;
(b) purge (i.e. make liquid and vapour free) bunkering lines/pipes;
(c) confirm that bunkering lines/pipes are free of fuel upon completion of bunkering.

Liquid shall be discharged to the fuel storage tanks or other suitable location.

6.2.7 Physical arrangements shall be provided for safe management of any spilled fuel during bunkering. This shall include drip trays fitted below bunkering connections and where leakage may occur. Each drip tray shall be:

(a) made of suitable material to hold spills, *see Ch 1, 4 Materials, components and equipment*;

(b) fitted with a means to safely dispose of spills, *see Ch 1, 7.3 Drainage arrangements*;

(c) fitted with a drain valve to enable rainwater to be drained over the ship's side;

(d) of sufficient capacity to handle reasonably foreseeable spills.

6.2.8 The bunkering manifold shall be designed to withstand external loads during bunkering. The connections at the bunkering station shall be of dry-disconnect type equipped with additional safety dry break-away coupling/self-sealing quick release. The couplings shall be of an approved type.

6.2.9 The ship shall be fitted with an Emergency Shutdown (ESD) System operable from both the ship and the bunker supply facility. This shall be arranged to ensure rapid and safe shutdown of both the bunker supply and the ship's fuel supply system without release of liquid or vapour.

6.3 Fuel storage tanks

6.3.1 Fuel storage tanks, including their design, materials, construction and testing shall be in accordance with the requirements of Chapters LR V, LR VI, 4, 6, 8 and 15 of the LR Rules for Carriage of Liquid Chemicals in Bulk.

6.3.2 All tank connections, fittings, flanges and tank valves shall be enclosed in a cofferdam or a space meeting the requirements of a cofferdam, *see Ch 1, 6.4 Cofferdams* .

6.3.3 Fuel storage tanks shall have a tank master isolation valve located as near to the tank outer shell as is practicable. This valve shall be capable of remote and local manual operation and provide full closure.

6.3.4 Arrangements shall be provided to:

(a) safely drain and empty fuel from the fuel storage tanks;

(b) safely purge (i.e. make liquid and vapour free) and vent the fuel storage tanks.

6.3.5 For single fuel installations (methanol only), the fuel storage shall be arranged in no fewer than two tanks so that, in the event of any one tank becoming unavailable, the remaining tank(s) will provide sufficient fuel to enable the ship to operate within its service profile, as defined in *Ch 1, 2.1 Documentation required for design review 2.1.1*. The tanks shall be located in separate fire-protected compartments.

6.3.6 Fuel storage tanks, supports and tank connections shall be designed to withstand loading from expected and reasonably foreseeable sloshing of tank contents.

6.3.7 Fuel storage tanks shall withstand, without leakage, the maximum static and dynamic pressures (and vacuum) expected during purging and inerting, and the maximum static and dynamic pressures that can be reasonably expected in the event of a deviation from 'normal' or intended purging and inerting.

6.3.8 Fuel storage tanks shall withstand, without leakage, the maximum calculated pressure increase due to fuel returning to the tank.

6.3.9 It shall be possible to isolate, drain and transfer fuel storage tank contents remotely from a safe location.

6.3.10 The maximum degree of filling of fuel tanks shall be 98 per cent. This is the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded.

6.3.11 The fuel storage tank venting system shall be designed with redundancy for the relief of full flow overpressure and/or vacuum.

6.3.12 The opening pressure of the vacuum relief valves is not to be lower than 0,07 bar below atmospheric pressure.

6.3.13 The outlet from the pressure relief valves shall normally be located at least $B/3$ or 6 m, whichever is greater, above the weather deck and 6 m above the working area and gangways, where B is the greatest moulded breadth of the ship in metres. The outlet from pressure relief valves shall be led to the opening at least 10 m from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or open decks which are accessible to personnel, or other non-hazardous spaces. It is also to be located at least 10 m from the nearest exhaust outlet from machinery installations.

6.3.14 Independent fuel storage tanks shall be designed to avoid accumulation and subsequent discharge of static electricity resulting from bunkering and fuel transfer. The following requirements shall be satisfied:

(a) Fuel flow into and out of the tank shall be controlled to minimise turbulence and avoid accumulation of static electricity.

(b) Tank filling arrangements shall be designed to avoid free-falling of fuel through air to prevent air entrainment, absorption of moisture, and accumulation of static electricity in the falling liquid.

(c) The fuel storage tank and the bunkering and supply piping system shall be electrically grounded in accordance with the Rules.

6.3.15 Independent fuel storage tanks and their supports shall be designed to withstand all reasonably foreseeable loading.

6.3.16 Independent fuel tanks shall be provided with arrangements to ensure any leakages are contained, *see Ch 1, 7.3 Drainage arrangements*

6.3.17 Portable fuel tanks may be specially considered. Such tanks shall meet the requirements of this sub-Section as applicable and shall be included in the risk-based studies, *see Ch 1, 3.1 Purpose*.

6.4 Cofferdams

6.4.1 Cofferdams or spaces meeting the requirements of cofferdams shall safely contain leakage from fuel tanks, tank connections, fittings, flanges and tank valves without this leakage spreading to other spaces.

6.4.2 The cofferdam shall be designed to withstand the weight of accumulated liquid from a maximum credible leakage scenario into the cofferdam, *see* Rules for Ships, *Pt 4, Ch 1, 9.2 Watertight and deep tank bulkheads 9.2.1*.

6.4.3 Cofferdams shall be protected from external heat sources.

6.4.4 Cofferdams and pump rooms shall be considered hazardous and shall be arranged with continuous liquid and vapour detection. Liquid detection may be achieved through liquid level monitoring, *see also Ch 1, 7.2 Piping design 7.2.20*

6.4.5 Ventilation shall be in accordance with the requirements for cofferdams in the Rules for Carriage of Liquid Chemicals in Bulk, *Ch 1, 12.3 Spaces not normally entered*.

6.4.6 Cofferdams shall be provided with a suitable means of removing fuel.

6.5 Methanol supply system

6.5.1 The fuel supply to each consumer shall be equipped with a manually operated isolation valve and an automatically operated master fuel valve coupled in series. The master fuel valve shall be closed and the fuel pump shall be shut down:

(a) automatically in the event of:

  (i) liquid detection, and/or detection on two vapour detectors within the machinery space containing the consumers;
  (ii) loss of the required ventilation from the pipe duct or casing;
  (iii) loss of pressurisation of double-walled piping;
  (iv) detection of a leak in the pipe duct, double-walled piping, or cofferdam;

(b) using manual controls that are:

  (i) located remotely from the valve;
  (ii) in accessible positions within the machinery space containing the methanol-fuelled consumers;
  (iii) at a suitable location outside the machinery space;
  (iv) at a location on the navigation bridge.

6.5.2 The number and location of manual controls shall be agreed with LR. Where dual-fuel engines are installed, these locations shall correspond with those required for shutting off fuel oil, *see* Rules for Ships, *Pt 5, Ch 14, 4 Fuel oil pumps, pipes, fittings, tanks, etc.*.

6.5.3 Depending on the propulsion and machinery arrangement, a separate and independent fuel supply line shall be provided for each consumer.

6.5.4 The fuel line to each consumer shall be fitted with a means of purging the pipework downstream of the master fuel valve of fuel (liquid and vapour). This shall happen automatically where the master fuel valve in *Ch 1, 6.5 Methanol supply system 6.5.1* is automatically closed.

6.5.5 The provisions within *Ch 1, 6.5 Methanol supply system 6.5.1* and *Ch 1, 6.5 Methanol supply system 6.5.4* shall be arranged for manual reset. Arrangements shall ensure that the fuel supply is not resumed until the abnormal condition that caused the shut-off of the valves has been rectified and it is safe to resume supply.

6.5.6 All fuel valves shall be arranged for both local operation and remote operation from the machinery control station.

6.5.7 For installations with a single source of propulsion power, arrangements shall be such that, in case of loss of the fuel supply, a secondary separate and independent fuel supply shall be available. Dual-fuelled consumers shall be capable of operating at their maximum continuous rating on fuel oil alone.

6.5.8 Where necessary, the fuel system shall include suitable equipment to provide fuel at constant temperature and pressure. In all cases, arrangements shall be such that the fuel storage and delivery systems are maintained at a pressure below any relief device set pressure.

6.5.9 Master fuel valves are not to be located within a machinery space.

6.5.10 All fuel supply piping within non-hazardous areas shall be enclosed in a gastight enclosure, i.e. double-walled piping or ventilated gastight ducting.

6.5.11 Prime movers for fuel supply equipment, such as engines and motors, shall be of a certified safe type suitable for the space in which they are installed or shall be located in an adjacent non-hazardous area. Prime mover shafts passing through bulkheads or decks shall be fitted with gastight seals of an approved type.

6.5.12 The arrangement and installation of the fuel piping shall provide the necessary flexibility to accommodate the movements of the machinery in order to minimise the likelihood of failure due to fatigue. The length and configuration of the branch lines are important factors in this regard.

6.5.13 All pumps in the fuel system shall be protected against running dry (i.e. protected against operation in the absence of fuel or service fluid).

6.5.14 All pumps which are capable of developing a pressure exceeding the design pressure of the system shall be provided with relief valves. Each relief valve shall be in closed circuit, i.e. arranged to discharge back to the piping upstream of the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

6.5.15 Pumps and supports shall safely accommodate expected levels of vibration.

6.5.16 Pumps within accessible spaces shall be protected from impact damage.

6.6 Methanol-fuelled reciprocating internal combustion engines and turbines

6.6.1 All engine components, systems and sub-systems shall be designed to prevent explosion so far as is reasonably practicable.

6.6.2 When fuel is supplied in a mixture with air through a common manifold, sufficient flame arrestors shall be installed before each cylinder head. The inlet system shall be designed to withstand explosion of a fuel-air mixture by means of:

(a) explosion relief venting to prevent excessive pressure build-up; where explosion relief venting is installed, it shall discharge the combustion products to a safe location;
(b) having sufficient strength to contain a worst-case explosion, in which case, documentary evidence shall be submitted.

6.6.3 The requirements in *Ch 1, 6.6 Methanol-fuelled reciprocating internal combustion engines and turbines 6.6.2* may be omitted if the fuel concentration within the manifold is controlled and if combustion of an unburnt mixture within the manifolds can be eliminated. A justification to demonstrate how this can be achieved shall be submitted.

6.6.4 The exhaust system of engines shall be designed to withstand combustion of unburnt fuel-air mixture by means of:

(a) explosion relief venting to prevent excessive pressure build-up; where explosion relief venting is installed, it shall discharge the combustion products to a safe location;
(b) having sufficient strength to contain a worst-case explosion, in which case, documentary evidence shall be submitted; or
(c) temperature-limiting arrangements to prevent the exhaust system exceeding the auto-ignition temperature of the methanol in addition to eliminating sources of ignition.

6.6.5 The requirements in *Ch 1, 6.6 Methanol-fuelled reciprocating internal combustion engines and turbines 6.6.4* may be omitted if combustion of an unburnt mixture within the manifolds can be eliminated. A justification to show how this can be achieved shall be submitted.

6.6.6 Engines shall be monitored to detect misfiring. Correct operation of the ignition system shall be verified before admission of fuel to the engine. The ignition system shall be designed such that it cannot shut down without first closing off the supply of methanol to each cylinder or to the complete engine.

6.6.7 Dual-fuel engines shall be capable of immediate changeover to fuel oil at any load in the event of the methanol fuel supply being shut off and thereafter capable of continuous operation at any load up to full load on fuel oil alone. In general, fuel oil shall be used when starting the engine, when the operation of the engine is unstable, and/or during manoeuvring and port operations.

6.6.8 In the case of a normal stop or an emergency shutdown, the methanol fuel supply shall be shut off no later than the fuel oil. It shall not be possible to shut off the supply of pilot fuel without first or simultaneously closing the methanol supply to each cylinder or to the complete engine.

6.6.9 All reciprocating internal combustion engines shall be provided with crankcase explosion relief valves fitted in way of each crankthrow. The valves shall be in accordance with *Pt 5, Ch 2 Reciprocating Internal Combustion Engines*, of the Rules for Ships.

6.6.10 All reciprocating internal combustion engines shall be fitted with oil mist monitoring equipment that is in accordance with the requirements of *Pt 5, Ch 2 Reciprocating Internal Combustion Engines*, of the Rules for Ships, or engine bearing monitoring devices or equivalent devices.

6.6.11 Where trunk piston type engines are used, a means of injecting inert gas into the crankcase is to be provided and the crankcase is to be protected by the following measures:

(a) The provision of breathing equipment, the outlet for which shall be led to a safe location in the open through a flame arrestor. Each engine shall have its own breather and the outlet lines of different engines are not to be connected;

(b) The provision of methanol detection equipment which is suitable for hazardous areas **zone 1**, *see Table 1.8.2 Methanol-fuelled consumers: Alarms, monitoring and safeguards*.

The safety philosophy and corresponding arrangements for prevention of crankcase explosions shall be documented and submitted. If such an arrangement cannot be achieved, equivalent safety measures shall be submitted for special consideration and acceptance by LR.

6.6.12 Vapour detection equipment for the piston underside space of engines shall be provided and shall activate engine shutdown in the event of high levels of vapour concentration. Means for the injection of inert gas are also to be provided.

6.6.13 The exhaust gas manifold of engines shall be so designed as to allow the combustion of unburnt charge from an individual cylinder without detrimental effect.

6.6.14 Each cylinder is to be provided with its own fuel inlet valve, admitting fuel either to the cylinder or the air inlet port. The functioning of this valve shall be such that no fuel can pass to the exhaust during the scavenging period or to the inlet port after closure of the air inlet valve.

6.6.15 An isolating valve and flame arrestor shall be provided at the inlet to the fuel supply manifold for each engine. The isolating valve is to be arranged to close automatically in the event of low fuel pressure or cylinder misfire.

6.6.16 Arrangements shall be provided to enable purging of fuel from the exhaust system before the starting of an engine, after failure to start and following loss of ignition during operation of the engine. Interlocking devices shall be fitted to ensure that purging can be performed only when the isolating valve required by *Ch 1, 6.6 Methanol-fuelled reciprocating internal combustion engines and turbines 6.6.15* is closed. The purge is to be of sufficient duration to displace at least three times the volume of the exhaust system.

6.6.17 The exhaust pipes of methanol-fuelled engines, including gas turbines, shall not be connected to the exhaust pipes of other engines or systems.

6.6.18 Indication shall be provided for identifying poor combustion from each combustion chamber, flame-out and failure-to-ignite conditions, and arrangements shall be made to ensure that the fuel supply to the combustion chambers is cut off unless satisfactory ignition has been established and maintained.

6.6.19 The exhaust system shall be designed to prevent the accumulation of uncombusted fuel. Arrangements shall be provided to purge the turbine automatically before ignition commences on starting, or recommences after failure to start, or following a loss of ignition in operation. Interlocking devices shall be fitted to ensure that purging can be carried out only when the fuel supply valves are closed. The purge shall be of sufficient duration to displace at least three times the volume of the exhaust system. Combustion shall be monitored during operation and a means of preventing poor combustion, which may lead to an accumulation of unburnt methanol in the exhaust, shall be provided.

6.6.20 Where it is possible for fuel to enter engine auxiliary systems, such as lubricating oil and cooling water systems, then a means of extracting this methanol shall be fitted at the outlet from the engine with the vapour removed being vented to a safe location.

6.6.21 Dual-fuel engines shall be fitted with an automatic fuel changeover system which can change over from oil to methanol or from methanol to oil reliably and with a minimum fluctuation in load. This shall be demonstrated during engine trials and any operational limitations on changeover loads from oil to methanol shall be recorded. The system shall be capable of changeover from methanol to oil at all loads.

6.6.22 Where turbines are fitted in gastight enclosures, the enclosure shall be provided with a minimum of two ventilation fans, each rated to provide a minimum of 30 air changes per hour and each of these fans shall be fed from a separate source of supply with no single point of failure being capable of stopping both fans. Failure of this ventilation shall result in automatic shutdown of

the fuel supply. This shall be detected by means of monitoring air flow and it is not acceptable to use fan motor electrical supply monitoring for this purpose. The interior of the enclosure shall be protected in accordance with the requirements for machinery spaces containing methanol fuelled engines.

6.7 Methanol-fuelled boilers

6.7.1 The arrangement of boilers and burner systems shall comply with the requirements of *Pt 5, Ch 10 Steam Raising Plant and Associated Pressure Vessels*and *Pt 5, Ch 14 Machinery Piping Systems* of the Rules for Ships and 16.5 of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, as applicable. The whole boiler casing shall be gastight and each boiler shall have a separate uptake.

6.7.2 Combustion chambers and furnaces of boilers shall be designed such that pockets of fuel cannot accumulate.

6.7.3 Boilers and combustion units shall be provided with forced draught arrangements. Each boiler shall have its own forced draught system.

6.7.4 Means shall be provided so that, in the event of flame failure, the fuel supply to the burners is shut-off automatically, and alarms are activated.

6.7.5 Means shall be provided for automatically purging the fuel supply piping to the burners after the burners have been extinguished. Arrangements are also to be provided to allow manual purging. Interlocking devices shall be fitted to ensure that purging can be performed only when the burner fuel supply valves are closed.

6.7.6 For dual-fuel burner units, the firing equipment shall be suitable to burn either fuel oil or methanol alone, or fuel oil and methanol simultaneously. The burner shall maintain stable firing under all firing conditions and on main/propulsion boilers shall be fitted with an automatic fuel changeover system to change from methanol to oil operation with minimum impact to the flame.

6.7.7 The fuel changeover system shall be monitored and protected from damage (e.g. from high pressure, heat, electrical overload) so as to ensure continuous availability whilst the boiler is in operation. An interlocking device shall be provided to prevent the methanol fuel supply being opened until the oil and air controls are in the firing position. It shall be possible to change from methanol to fuel oil operation without interruption of boiler firing.

6.7.8 Each burner supply pipe shall be fitted with a fuel shut-off valve and a flame arrestor, unless this is incorporated in the burner. A means shall be provided to automatically purge the fuel supply to burners using inert gas or a suitable alternative after extinguishing the burner flames.

6.7.9 In addition to the low water-level oil-fuel shut-off and alarm required by *Pt 5, Ch 10, 15.7 Low water level fuel shut-off and alarm* or 16.7 of the Rules for Ships for oil-fired boilers, equivalent arrangements shall be made for fuel shut-off and alarms when the boilers are operating on methanol. "

6.8 Inert gas system

6.8.1 Provision shall be made for supply of nitrogen inert gas. This shall be either through on board generation of inert gas or through an inert gas storage system with provision for refilling from shore.

6.8.2 The inerting arrangements shall provide for:

(a) inerting of all fuel piping during normal operation and emergency shutdown activation;
(b) inerting of methanol-fuelled consumers;
(c) atmospheric control (e.g.., double wall piping annulus and maintaining tank vapour spaces in an inert condition at all times);
(d) fire protection systems.

6.8.3 The inert gas system shall be able to maintain a pressure of at least 0,007 MPa gauge within the fuel storage tank(s) at all times. The inert gas system shall not raise the fuel storage tank pressure to more than the tank's relief-valve setting.

6.8.4 The available inert gas capacity shall be continuously monitored and replenished before it is unable to meet the functional requirements of *Ch 1, 6.8 Inert gas system 6.8.2*.

6.8.5 The inerting supply arrangements are to meet the applicable requirements of the Rules for Ships, *Pt 5, Ch 15, 7 Inert gas systems on Tankers of 8,000 tonnes DWT and above*.

Section 7
Piping

7.1 General

7.1.1 The design and construction of piping shall be in accordance with Rules for Ships, *Pt 5, Ch 12 Piping Design Requirements*, Rules for Carriage of Liquid Chemicals in Bulk, *Ch 5 Process Pressure Vessels and Liquid, Vapour and Pressure Piping Systems* as applicable and these Rules. Piping material selection shall consider the system design pressure and temperature.

7.1.2 A Fatigue analysis shall be conducted for all pressurised piping arrangements subject to vibration or pulsating pressure, where failure of the pipe or its connection or a component could result in a safety hazard, e.g. fire. The analysis shall recognise the pressures and fluctuating stresses that the piping system may be subject to in normal service.

7.2 Piping design

7.2.1 Piping connections shall be reduced to the minimum required for installation and machinery maintenance. All piping shall be suitably and adequately supported so as to avoid, as far as is practicable, vibration that could lead to fatigue failure.

7.2.2 All valves and expansion joints used in pressurised fuel piping shall be of an approved type and suitable for the intended service.

7.2.3 Joints on the entire length of the fuel piping shall be butt-welded with full penetration and a minimum of 10 per cent of the piping system shall be fully radiographed, except where alternative means of NDE are approved by LR. Radiography of the piping shall be extended to 100 per cent where defects are detected.

7.2.4 Fuel pipe joints other than welded joints at the locations approved by LR shall comply with an appropriate standard recognised by LR, or with those joints whose structural strength has been verified through tests and analysis to the satisfactory requirements of LR.

7.2.5 Welding procedures shall be established for welding of pressurised fuel piping and submitted to LR for approval as detailed in the LR Rules for Materials. Suitable post-weld heat treatment shall be performed where indicated in the approval.

7.2.6 Fuel piping shall be clearly identifiable by means of a suitable colour code based on a recognised Standard, e.g. EN ISO 14726:2008 *Ships and marine technology - Identification colours for the content of piping systems*.

7.2.7 Piping installed shall be suitably located and protected from corrosion and from impact, such as from collision, grounding and dropped objects.

7.2.8 The wall thickness of fuel piping is not to be less than that given by the requirements of the LR Rules for Carriage of Liquid Chemicals in Bulk *Ch 1, 5.1 Piping scantlings*.

7.2.9 The design pressure for any section of the fuel piping system is the maximum gauge pressure to which the system may be subjected in service, taking into account the highest set pressure on any relief valve on the system.

7.2.10 Fuel piping systems shall have sufficient strength to accommodate stresses due to the weight of the piping system, acceleration loads (if significant), and internal pressure and loads induced by hog and sag of the ship, *see* Rules for Ships,*Pt 3, Ch 4 Longitudinal Strength*.

7.2.11 All piping and components containing fuel that may be isolated shall be provided with relief valves.

7.2.12 Piping into the fuel storage tank, fittings, flanges, valves or other equipment in the tank space shall be minimised."

7.2.13 Fuel piping is not to be located less than 800 mm from the ship's side.

7.2.14 Fuel piping shall be entirely separate from other piping systems and is not to pass through accommodation, service spaces and control stations.

7.2.15 Fuel piping within a machinery space shall comply with the applicable requirements in *Ch 1, 7.2 Piping design 7.2.16*. Alternative arrangements to those stated in *Ch 1, 7.2 Piping design 7.2.17* and *Ch 1, 7.2 Piping design 7.2.18* will be considered where an equivalent level of safety for personnel, equipment and the ship can be demonstrated.

7.2.16 All fuel supply piping within enclosed spaces, including machinery spaces, shall be enclosed in a secondary gastight and liquid-tight enclosure of the following type:

(a) double-walled piping or ventilated ducting provided with forced draught ventilation, *see Ch 1, 7.2 Piping design 7.2.18*;

(b) double-walled piping with the annular space between pipes pressurised with inert gas, *see Ch 1, 7.2 Piping design 7.2.17*; or
(c) cofferdam, *see Ch 1, 6.4 Cofferdams* .

7.2.17 Where fuel piping is a double-walled piping system with the fuel contained in the inner pipe, and the annular space between pipes is pressurised with inert gas, the following requirements shall be satisfied:"

(a) "the annular space between pipes shall be pressurised with inert gas to a pressure greater than the fuel pressure;"
(b) alarms shall be provided to indicate loss of pressure between the pipes;
(c) the pressure in the annular space shall be monitored continuously and, before the pressure falls below the inner pipe pressure, the master fuel valve specified in *Ch 1, 6.5 Methanol supply system 6.5.1* shall be arranged to close;
(d) construction and strength of the outer pipes shall be based on the design pressure of the inert gas or the most onerous inner pipe leakage whichever is higher.

7.2.18 Where the fuel piping is installed within a gastight double-walled pipe or ventilated gastight ducting with forced draught ventilation, the following requirements shall be satisfied:

(a) the air space between the fuel piping and the duct inner wall shall be provided with mechanical ventilation having a capacity that takes into account the construction and arrangement of protective pipes or ducts and shall ensure at least 30 air changes per hour;
(b) ventilation shall maintain a pressure less than the atmospheric pressure. The fan motors shall be placed outside the ventilated pipe or duct;
(c) ventilation outlets shall be located to discharge at least 3 m above deck and 3 m away from the nearest air intakes or openings to accommodation and enclosed working spaces, and from possible sources of ignition;
(d) ventilation intakes shall be located in non-hazardous area and be provided with automatic non-return devices that prevent the escape of methanol or alternatively, a vapour detector shall be fitted at each air intake;
(e) ventilation shall be arranged to be in operation whenever there is fuel in the piping;
(f) continuous vapour detection shall be arranged in the ventilation system to provide an indication at the machinery control station of leaks and to shut down the fuel supply to the machinery space in accordance with *Ch 1, 8.4 Methanol vapour detection 8.4.12*;
(g) the master fuel valve required by *Ch 1, 6.5 Methanol supply system 6.5.1* shall be arranged to close automatically if the required airflow is not established and maintained by the exhaust ventilation system;
(h) the materials, construction and strength of outer protection pipes or ducts and the mechanical ventilation systems shall be capable of withstanding the sudden emission and expansion of pressurised methanol in the event of failure of an inner methanol pipe;
(i) the number of flange joints of outer protective pipes or ducts shall be minimised;
(j) the outer protection piping or ducting shall be pressure-tested to the maximum working pressure of the inner pipe;
(k) ventilation performance required by this Section shall be maintained at all expected temperatures and environmental conditions as defined in the Design Statement, *see Ch 1, 2.1 Documentation required for design review 2.1.1*.

7.2.19 Where fuel is contained in double-walled piping or piping within ducting, the outer barrier shall remain gas- and liquid-tight in the event of leakage of the primary pipe taking into consideration the impingement force and the effects of pressurised expansion.

7.2.20 The annular space of double-walled piping or piping within ducting shall be fitted with a means of providing liquid leak detection from the inner pipe. This may comprise drainage to a tank that is fitted with liquid level detection, *see Ch 1, 8 Control, alert and safety systems* . This tank shall be separate from the bilge holding tanks referred to in *Ch 1, 7.3 Drainage arrangements* and the space in which it is located shall be considered hazardous, *see also Ch 1, 7.3 Drainage arrangements 7.3.5*.

7.2.21 The annular space of double-walled piping or piping within ducting shall be fitted with drains leading to the bilge holding tanks referred to in *Ch 1, 7.3 Drainage arrangements*. These drains shall be fitted with valves that open automatically on detection of leakage, *see Ch 1, 7.2 Piping design 7.2.20* and *Table 1.8.1 Methanol fuel supply and storage: Alarms, monitoring and safeguards*.

7.2.22 The slope of pipes and the number and position of drain points shall be such that fuel can be efficiently drained from any portion of the piping system, taking into consideration the requirements of the Rules for Ships, *Pt 5, Ch 1, 3.6 Ambient operating conditions* and *Ch 1, 3.7 Bunkering safety study*.

7.3 Drainage arrangements

7.3.1 Drip trays shall be provided to manage leakages and spills of fuel.

7.3.2 Each drip tray that is located in an enclosed space shall be fitted with a drain valve to enable drainage to a dedicated bilge holding tank.

7.3.3 One or more bilge holding tanks for collecting drainage and any possible leakage of fuel from pumps, valves and from double-walled pipes and ducts located in enclosed spaces shall be provided.

7.3.4 Bilge holding tanks shall meet the relevant requirements of *Ch 1, 6.3 Fuel storage tanks*.

7.3.5 The area in which the bilge holding tank(s) is located shall be considered hazardous. Alternative arrangements (e.g. dilution of the methanol to maintain the solution below its lower flammable limit) may be accepted where supported in the risk-based studies, *see Ch 1, 3 Risk-based studies*.

7.3.6 The bilge system serving the fuel pump room shall be operable from outside the fuel pump room.

7.3.7 Drip trays and coamings shall have sufficient capacity to accommodate the maximum credible spill of fuel identified by the risk-based studies. The maximum credible spill scenario is to be determined and agreed with LR.

7.3.8 Bilge holding tanks shall have sufficient capacity to accommodate the maximum credible leakage of fuel identified by the risk-based studies. The maximum credible leakage scenario is to be determined and agreed with LR.

7.3.9 A shore connection with a standard coupling or other facilities shall be provided for transferring contaminated fuel to onshore reception facilities.

7.3.10 Bilge holding tanks shall be provided with inerting arrangements as detailed in *Ch 1, 6.8 Inert gas system*.

7.3.11 Arrangements for managing leakages shall be capable of fulfilling their function under the operating conditions defined in Rules for Ships,*Pt 5, Ch 1, 3 Operating conditions*.

Section 8
Control, alert and safety systems

8.1 General

8.1.1 The requirements in this Section apply to all types of tanks, machinery and equipment.

8.1.2 Control, alert and safety systems shall comply with the relevant requirements of *Pt 5 Main and Auxiliary Machinery* and *Pt 6, Ch 1 Control Engineering Systems* of the Rules for Ships.

8.2 Control, alarm and safety functions

8.2.1 Alarms, monitoring and safeguards shall be provided for fuel supply equipment and consumers as indicated in *Table 1.8.1 Methanol fuel supply and storage: Alarms, monitoring and safeguards*. The Tables contain the minimum list of alarms, warnings and shutdowns for a methanol-fuelled installation. Additional alarms, warnings and shutdowns may be necessary as determined by the manufacturer or installation. A warning shall be provided in the event of any shutdown.

8.2.2 Any additional alarms and shutdowns determined on the basis of the risk-based studies shall be provided as necessary, *see Ch 1, 3 Risk-based studies*.

8.2.3 Arrangements shall be made so that the fuel supply to the consumers can be shut off manually from any space or area containing those consumers, the engine-starting platform or any other control position.

8.2.4 A local reading pressure gauge shall be fitted between the stop valve and the connection to shore at each bunker pipe.

8.2.5 Pressure gauges shall be fitted to fuel vapour return lines and to the bunkering lines.

8.2.6 For fuel storage tanks not permanently installed in the ship, the control, alarm and safety functions shall be provided as for permanently installed fuel storage tanks.

8.2.7 As a minimum, each fuel storage tank and bilge holding tank, *see Ch 1, 7.3 Drainage arrangements*, shall be provided with the following monitoring. The required alarms and shutdowns are noted in *Table 1.8.1 Methanol fuel supply and storage: Alarms, monitoring and safeguards*:

(a) vapour space pressure. Pressure indicators shall be clearly marked with the highest and lowest pressure permitted in the tank. The high pressure alarms shall be activated before the set pressures of the pressure relief valves;

(b) fuel temperature;

(c) liquid level.

8.2.8 The vapour space of each fuel storage tank shall be provided with a direct pressure gauge(s) which shall be located in a space that is close to the storage tank. This space shall be considered hazardous. Additionally, an indirect indication shall be provided at a machinery control station

8.2.9 Gauging devices for fuel temperature and liquid level shall be:

(a) closed devices, which penetrate the fuel tank, but which are part of a closed system and keep tank contents from being released, (e.g. a remote-reading thermometer of which the sensor is installed in the tank):
(b) arranged so that they can be maintained in an operational condition without the need to empty and vapour-free the tank unless two independent devices are provided;
(c) capable of being function-tested, such that all elements of the level alarms, including the electrical circuit and the sensor(s) of the high level alarm and high-high shutdown, can be tested.

8.2.10 The high level alarm and independent high-high level shutdown required in *Table 1.8.1 Methanol fuel supply and storage: Alarms, monitoring and safeguards* shall be provided with an audible signal and visual indication when activated. The high-high set-point is to be taken from an independent sensor and shall actuate a shut-off valve in a manner that will both avoid excessive fuel pressure in the bunkering line and prevent the tank from becoming liquid full, *see also Ch 1, 6.2 Methanol bunkering system 6.2.2*. Indication shall be provided at the location referred to in *Ch 1, 6.2 Methanol bunkering system 6.2.1*.

8.2.11 Each fuel pump discharge line and each methanol fuel manifold shall be provided with at least one local pressure indicator.

8.2.12 Alarms shall be provided to indicate low input pressure, low output pressure, high output pressure, high output temperature and failure of operation of fuel pumps using audible signals and visual indications both on the navigation bridge and in the engine room.

8.2.13 Doors to air-locks shall be monitored. Indication shall be provided at each door, such as a flashing light either side of each door to indicate when one door is open. In addition, an alarm with an audible signal and visual indication shall be provided at the machinery control position and on the navigating bridge when both doors are opened.

8.2.14 Ventilation to, and within, air-locks shall be monitored. An alarm shall be provided, with an audible signal and visual indication at the machinery control position and on the navigating bridge on loss of ventilation.

8.2.15 Indication shall be fitted on the navigation bridge, the engine control room and the manoeuvring platform to show:

(a) operational parameters of the consumer, as appropriate to the type of consumer, where single fuel engines are used; and
(b) (b) operational parameters of the consumer, as appropriate to the type of consumer, and which fuel the consumer is operating on, where dual-fuel engines are used.

8.3 Pressurisation

8.3.1 For protective measures to be taken in the event of failure of pressurisation, *see* Table 5 of IEC 60092-502 *Electrical installations in ships- Part 502: Tankers – Special Features*.

8.4 Methanol vapour detection

8.4.1 A permanently-installed system of methanol vapour detection providing an alarm with an audible signal and visual indication shall be fitted in:

(a) all enclosed spaces containing fuel supply piping and equipment or consumers, e.g. machinery spaces, cofferdams, fuel processing rooms, valve rooms;
(b) other enclosed or semi-enclosed spaces where vapours may accumulate, including bunker stations and exhaust uptakes;
(c) air-locks;
(d) fuel outer pipes or casing where required by *Ch 1, 6.5 Methanol supply system 6.5.10* and *Ch 1, 7.2 Piping design*;
(e) outlets of, or points within, the double-walled piping or ventilated gastight ducting as per *Ch 1, 7.2 Piping design 7.2.18*;
(f) any spaces requiring vapour detection as identified in the risk-based studies, *see Ch 1, 3 Risk-based studies*.
(g) vent outlet from Otto cycle engine crankcases and lubricating oil purifiers; and
(h) vent outlet from Otto cycle engine cooling water expansion tank.

8.4.2 Methanol vapour detection equipment shall be designed, installed and tested in accordance with IEC 60079-29-1: *Explosive atmospheres - Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases* and shall be

suitable for the vapours to be detected. The equipment shall be self-monitoring such that failure of the control panel, detector heads or sampling unit provides an alarm with an audible signal and visual indication.

8.4.3 The number and the positions of detection heads or sampling heads shall be determined with due regard to the size and layout of the compartment, the dilution from compartment purging or ventilation and stagnant areas, and the manufacturer's recommendations.

8.4.4 The detector or sampling heads of the vapour detection systems are not to be located where liquid can collect. Pipe runs from sampling heads are not to be led through non-hazardous spaces, except as permitted by *Ch 1, 8.4 Methanol vapour detection 8.4.10*.

8.4.5 Alarms from vapour detection equipment required by *Ch 1, 8.4 Methanol vapour detection 8.4.1* shall initiate an audible signal and visual indication:

(a) on the navigating bridge;

(b) at the relevant control station(s) where continuous monitoring of the vapour levels is recorded;

(c) in the bunkering control position.

8.4.6 Permanently installed vapour detection shall be of the continuous detection type, capable of immediate response. Where not used to activate safety shutdown functions required by these Rules, the sampling type detection may be accepted.

8.4.7 In the selection of detectors for locations identified in *Ch 1, 8.4 Methanol vapour detection 8.4.1.(g)* and *Ch 1, 8.4 Methanol vapour detection 8.4.1.(h)*, due consideration shall be taken of temperature and humidity of the environment in which the vapour is being detected. For sampling systems, the system shall include a method to dry and cool the sampled environment to that in which methanol can be accurately detected.

8.4.8 When sampling type detection equipment is used, the following requirements shall be met:

(a) the detection equipment shall be capable of sampling and analysing for each sampling head location sequentially at intervals which are as short as possible but do not exceed 30 minutes;

(b) individual sampling lines from sampling heads to the detection equipment shall be fitted; and

(c) pipe runs from sampling heads are not to be led through non-hazardous spaces, except as permitted by *Ch 1, 8.4 Methanol vapour detection 8.4.9*.

8.4.9 Sampling type detection equipment may be located in a non-hazardous space, provided that the detection equipment, such as sample piping, sample pumps, solenoids and analysing units, is located in a fully-enclosed steel cabinet with the door sealed by a gasket. The atmosphere within the enclosure shall be continuously monitored. At vapour concentrations above 30 per cent LEL inside the enclosure, the entire detection unit shall be automatically shut down, including all power to external equipment.

8.4.10 Additionally, where sampling type detection equipment is located in a non-hazardous space, the following conditions are also to be satisfied:

(a) vapour sampling lines shall have shut-off valves, or an equivalent arrangement, to prevent cross-communication with hazardous spaces; and

(b) exhaust vapours from the detector shall be discharged to the atmosphere in a safe location.

8.4.11 Detection equipment shall be designed so that it may be readily tested. Testing and calibration shall be capable of being carried out at regular intervals. Arrangements shall be made for suitable equipment and span gas for testing and calibration purposes to be carried on board. Wherever practicable, provision shall be made for permanent connections for attachment of testing and calibration equipment.

8.4.12 Detection system(s) shall be suitable for measuring vapour concentrations of 0 to 100 per cent by volume of the LEL. Alarms shall be activated when the fuel vapour concentration reaches 30 per cent of the LEL and automatic closing of supply line master fuel valve shall occur when the vapour concentration reaches 60 per cent of the LEL. Common sampling lines to the detection equipment are not to be fitted.

8.5 Fire detection and alarm system

8.5.1 Fire detection and alarm systems satisfying the requirements of *Pt 6, Ch 1 Control Engineering Systems* and *Pt 6, Ch 2 Electrical Engineering* of the Rules for Ships, shall be fitted in all spaces containing potential sources of fuel leakage and ignition.

8.6 Bunkering system

8.6.1 At least two reliable and independent means of communication shall be provided for maintaining communication between the ship and the bunkering supplier during bunkering operations. Systems shall be linked ESD systems as required by *Ch 1, 6.2 Methanol bunkering system 6.2.9* and comply with a recognised standard that is acceptable to LR.

8.6.2 A local pressure indicator shall be provided to indicate the pressure between the ship's manifold valves and hose connections to the bunker supply.

Table 1.8.1 Methanol fuel supply and storage: Alarms, monitoring and safeguards

Item	Condition	Response and Notes
Fuel supply	Abnormal pressure Abnormal temperature	Audible and visual alarm on the navigation bridge and in the engine room. *See* Note 4
Valve actuating medium	Loss	Fuel supply shutdown, *see* Note 1
Supply line pipe duct or casing ventilation	Failure	Fuel supply shutdown, *see* Notes 1 to 3 Automatic closing of supply line master fuel valve, *see Ch 1, 7.2 Piping design 7.2.18* and Note 6.
Double-walled piping	Liquid leakage detection, *see* Note 9 *Loss of pressurisation or ventilation*	Fuel supply shutdown, *see* Notes 1 to 3 Automatic closing of supply line master fuel valve, *see Ch 1, 7.2 Piping design 7.2.17*, *Ch 1, 7.2 Piping design 7.2.18* and Note 6. For bunkering lines, *see* Note 8 For fuel shore connection shutdown arrangements, *see Ch 1, 6.2 Methanol bunkering system 6.2.9*
Exhaust purging	Failure	Alarm. *See Ch 1, 6.6 Methanol-fuelled reciprocating internal combustion engines and turbines 6.6.19*
Fuel storage tanks	High level	Bunkering alarms shall be given in bunkering control station, *see Ch 1, 6.2 Methanol bunkering system 6.2.1* for monitoring
Fuel storage tanks	High pressure, high temperature, high-high level, overfill, low pressure (if vacuum tank)	Methanol bunkering shutdown, *see Ch 1, 8.2 Control, alarm and safety functions 8.2.10* and Note 4.
Fuel storage hold space or cofferdam	Fire detection	Closing of the tank master isolation valve.
Bunkering	Bunker line high pressure, loss of communication	Methanol bunkering shutdown

Machinery space	Fire detection	Audible and visual alarm on the navigation bridge or at a continuously manned location
Space ventilation system	Failure	Audible and visual alarm on the navigation bridge or at a continuously manned location
Cofferdams and pump rooms	Liquid or vapour detection	Fuel supply shutdown within the space in which it is detected

Note 1. Fuel supply shutdown by automatic operation of methanol supply line master fuel valves.

Note 2. Alarms associated with fuel supply and ventilation arrangements shall be given in the machinery space and machinery control station.

Note 3. *See Ch 1, 6.5 Methanol supply system 6.5.7* for alternative methanol fuel supply requirements

Note 4. High temperature to result in methanol fuel supply shutdown.

Note 5. Fire detection in spaces containing methanol-fuelled equipment or in adjacent spaces to result in methanol fuel supply shutdown.

Note 6. Actual valve position shall be positively indicated at the required remote control position.

Note 7. Arrangements shall prevent automatic or remote starting under conditions which could cause a hazardous situation, *see* Rules for Ships, *Pt 5, Ch 1, 3.10 Machinery interlocks 3.10.1*.

Note 8. Alarm shall be given at the methanol fuel bunkering control station.

Note 9. Automatic drain valve opening to holding tanks, *see Ch 1, 7.2 Piping design 7.2.20* and *Ch 1, 7.2 Piping design 7.2.21*

Table 1.8.2 Methanol-fuelled consumers: Alarms, monitoring and safeguards

Item	Condition	Response and Notes
Engine crankcase protection	High methanol concentration	Alarm *See* Note 1 For methanol detection equipment requirements, *see Ch 1, 8.4 Methanol vapour detection*
Crosshead type engine piston underside spaces	High methanol concentration	Alarm *See* Note 1 For methanol detection equipment requirements, *see Ch 1, 8.4 Methanol vapour detection*
Engine fuel supply pressure	Low	Automatic closing of methanol supply manifold isolating valve. For alternative methanol fuel supply requirements, *see Ch 1, 6.5 Methanol supply system 6.5.7*

Engine fuel injection	Cylinder misfire Methanol fuel or pilot fuel injection Valve failure	Alarm *See* Note 2 *See Ch 1, 6.5 Methanol supply system 6.5.7* and *Ch 1, 6.6 Methanol-fuelled reciprocating internal combustion engines and turbines 6.6.15*
Exhaust methanol vapour temperature	High	Alarm Per cylinder, *see* Note 2
Exhaust methanol vapour temperature deviation from average	High	Alarm Per cylinder, *see* Note 2
Cylinder pressure	Low	Alarm Alternatively, ignition failure monitoring and alarms of each cylinder are permitted, *see* Note 2
Engine shutdown		Automatic closing of methanol supply manifold isolating valve
Burner flame and ignition	Failure	Alarm Each burner to be monitored, *see* Note 3
Boiler shutdown		*See also* Notes 2 and 3
Fuel injection valve cooling water pressure	Low	Alarm
Fuel injection valve cooling water temperature	High	Alarm

Note 1. Alarm set point to allow sufficient time for corrective action necessary to avoid increased risk of explosion. Alarm set point not to exceed LEL.

Note 2. Automatic operation of supply line master fuel valve, *see Ch 1, 6.5 Methanol supply system 6.5.1* to *Ch 1, 6.5 Methanol supply system 6.5.6*.

Note 3. Combustion spaces shall be purged automatically before re-ignition takes place in the event of flame-out on all burners. *See also Ch 1, 6.7 Methanol-fuelled boilers*.

Note 4. Machinery alarms shall be given in the machinery space and the machinery control station, in accordance with *Pt 6, Ch 1, 2.3 Alarm systems, general requirements 2.3.2* of the Rules for Ships.

Table 1.8.3 Methanol detection: Locations - Alarms, monitoring and safeguards

Monitored locations	Condition	Response and Notes
Locations described in *Ch 1, 8.4 Methanol vapour detection 8.4.1*, (*Ch 1, 8.4 Methanol vapour detection 8.4.1.(b)*), (*Ch 1, 8.4 Methanol vapour detection 8.4.1.(c)*), (*Ch 1, 8.4 Methanol vapour detection 8.4.1.(d)*), (*Ch 1, 8.4 Methanol vapour detection 8.4.1.(f)*), (*Ch 1, 8.4 Methanol vapour detection 8.4.1.(g)*), (*Ch 1, 8.4 Methanol vapour detection 8.4.1.(h)*)	Vapour concentration above 30% LEL	Alarm, *See* Notes 1, 2, 5 and 6
Fuel supply line ventilated pipe or ducts as described in *Ch 1, 8.4 Methanol vapour detection 8.4.1.(e)*		Alarm, *see* Notes 1 and 2
		For alternative fuel supply requirements, *see Ch 1, 6.5 Methanol supply system 6.5.7*
Within air intakes as described in *Ch 1, 7.2 Piping design 7.2.18.(d)*		Alarm, *see* Notes 1 and 2
Methanol analysing equipment cabinet		Alarm

Note 1. Alarm to be given additionally in the machinery space and the machinery control station.

Note 2. Continuous detection is required and fuel supply shall be shut down by automatic closing of supply line master fuel valve when the vapour concentration reaches 60% LEL, *see Ch 1, 8.4 Methanol vapour detection 8.4.12*.

Note 3. For fuel vapour detection equipment requirements, *see Ch 1, 8.4 Methanol vapour detection*.

Note 4. For fuel detection within machinery, *see Table 1.8.2 Methanol-fuelled consumers: Alarms, monitoring and safeguards*.

Note 5. Separate alarms for each location to be provided in accordance with *Ch 1, 8.4 Methanol vapour detection 8.4.5*.

Note 6. Methanol detection in bunker station alarm to be given at the methanol bunkering control station.

Note 7. Alarm set point to allow sufficient time for corrective action necessary to avoid increased risk of explosion. Alarm set point not to exceed LEL.

Section 9
Electrical

9.1 General

9.1.1 The electrical installation shall be designed, constructed and installed in accordance with the requirements of *Pt 6, Ch 2 Electrical Engineering* of the Rules for Ships.

Section 10
Fire safety

10.1 General

10.1.1 Arrangements for Fire protection, detection and extinction shall be considered in the risk-based studies, consideration being given specifically to MSC/Circular.1002 - *Guidelines on Alternative Design and Arrangements for Fire Safety*.

10.1.2 For the purposes of these Rules, where used in SOLAS II-2, 1.6.2.1, the term 'cargo' shall also be read to refer to methanol fuel and so the relevant provisions shall apply.

10.2 Structural fire protection

10.2.1 Unless expressly provided below, any space containing equipment for fuel storage and preparation (such as pumps, compressors, heat exchangers, and pressure vessels) shall be regarded as a machinery space of category A for the purpose of determining the fire integrity of bulkheads and decks forming their boundaries.

10.2.2 Any boundary of accommodation spaces, up to navigating bridge windows, service spaces, control stations, escape routes and machinery spaces, facing fuel storage tanks on open deck, shall be made of A-60 class divisions, except wheelhouse windows which can be class A-0 (*see also Ch 1, 5.3 Fuel storage tanks 5.3.7*). In addition, fuel storage tanks shall be segregated from cargo in accordance with the requirements of the International Maritime Dangerous Goods (IMDG) Code (where the tanks are regarded as bulk packaging).

10.2.3 The boundaries separating cofferdams, fuel supply equipment spaces and ventilation trunks to such spaces shall be made of:

(a) A-60 class divisions, and for machinery rooms and other 'high fire risk' areas, the fire insulation shall be fitted on the machinery room side or other 'high fire risk' areas side; or

(b) A-0 class divisions where the spaces are tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces.

10.2.4 The fire protection of fuel pipes led through ro-ro spaces, special category spaces, and vehicle spaces shall be specially considered by LR depending on the use, arrangements and expected pressure in the pipes.

10.2.5 Bunkering stations shall be separated by A-60 class divisions towards machinery spaces of category A, accommodation spaces, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard can be reduced to class A-0 divisions.

10.3 Fire main

10.3.1 When fuel storage tanks are located on open deck, isolating valves shall be fitted in the fire main to isolate damaged sections of the fire main. Isolation of a section of fire main shall not deprive the fire line ahead of the isolated section from the supply of water.

10.4 Deck-fixed pressure water-spraying system

10.4.1 A water spray system shall be installed for cooling and fire prevention to cover exposed parts of fuel storage tank(s) located on open deck.

10.4.2 The water spray system shall also provide coverage for boundaries of the superstructures, compressor rooms, pump rooms, cargo control rooms, bunkering control stations, bunkering stations and any other normally occupied deck houses that face the fuel storage tank on open deck.

10.4.3 The water spray system shall meet the relevant requirements of MSC.1/Circular 1430.

10.4.4 For passenger ships to which the requirements of SOLAS Ch II-1/8-1 and Ch II-2 Reg 21 and 22 apply, the water spray system shall remain operational following any casualty as specified in SOLAS Ch II-1 Reg 8-1.2, Ch II-2, Reg 21.3 and Reg 22.3.1.

10.5 Deck foam fire-extinguishing system

10.5.1 A fixed, Alcohol Resistant Aqueous Film Forming Foam (ARAFFF) fire-extinguishing system shall be provided. Coverage and positioning of monitors of the ARAFFF system shall be addressed in the risk-based studies.

10.6 Fire-extinguishing arrangements in machinery spaces

10.6.1 A fixed fire-extinguishing system complying with the provision of MSC/Circ.1165 (as amended), shall be provided in machinery spaces where equipment containing fuel is located.

10.6.2 Additional fire-fighting measures shall be considered in the risk-based studies, *see also Ch 1, 10.1 General 10.1.1*.

Section 11
Testing and trials

11.1 Testing and trials

11.1.1 Testing of consumers and equipment shall be carried out in accordance with test schedules agreed by LR. In general, the arrangements for testing shall be equivalent to those required for oil-fuelled machinery and equipment.

11.1.2 Consideration will be given to carrying out methanol fuel tests when the ship is at sea where the engine and its control systems have previously been tested in the oil-fuelled operating mode to the satisfaction of LR.

11.1.3 Commissioning tests and trials shall be carried out in accordance with the testing programme which is required to be submitted by *Ch 1, 2.1 Documentation required for design review 2.1.1.(q)*, (*Ch 1, 2.1 Documentation required for design review 2.1.1.(r)*) and (*Ch 1, 2.1 Documentation required for design review 2.1.1.(t)*). The testing programme shall be agreed by LR and all tests shall be carried out in the presence of a Surveyor.

11.1.4 Trials shall include the testing of all alarms and safeguards associated with the fuel supply system and consumers and equipment. At first loading, the testing of high and high-high level alarms shall be conducted by raising the liquid level in the fuel tank to the alarm point. All elements of the level alarms, including the electrical circuit and the sensor(s), of the high and high-high alarms, shall be function tested.

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